Nov. 25, 1958 H. E. CRUMRINE ET AL 2,861,543

APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGE

Filed June 14, 1954 4 Sheets-Sheet 1

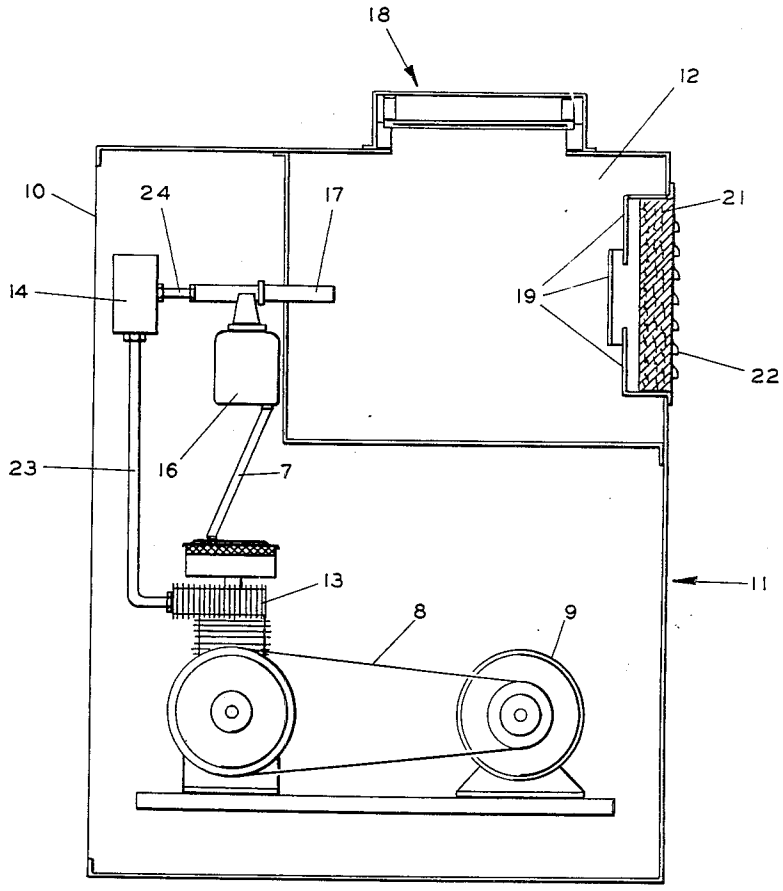


FIG. 1

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APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGE

Filed June 14, 1954 4 Sheets-Sheet 2

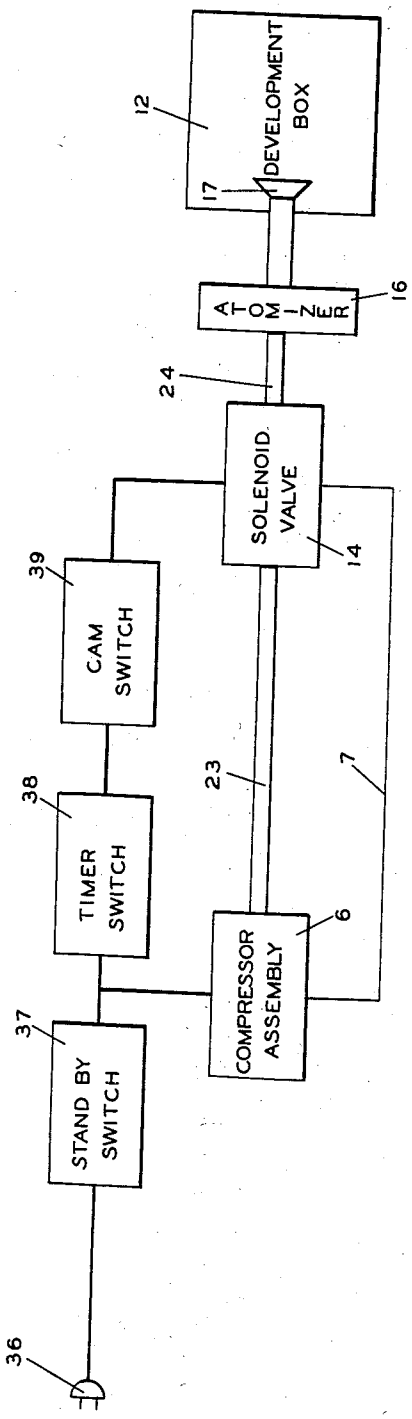


FIG. 2

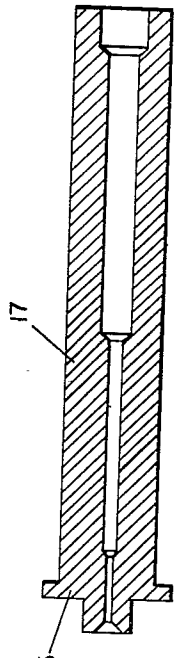


FIG. 3

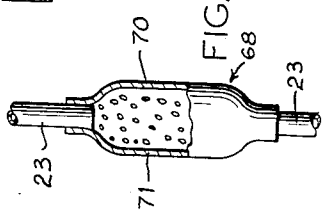


FIG. 1B

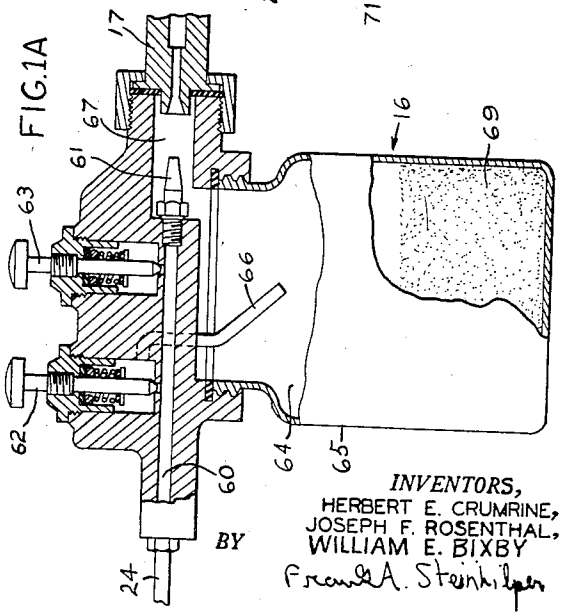


FIG. 1A

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APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGE

Filed June 14, 1954 4 Sheets-Sheet 3

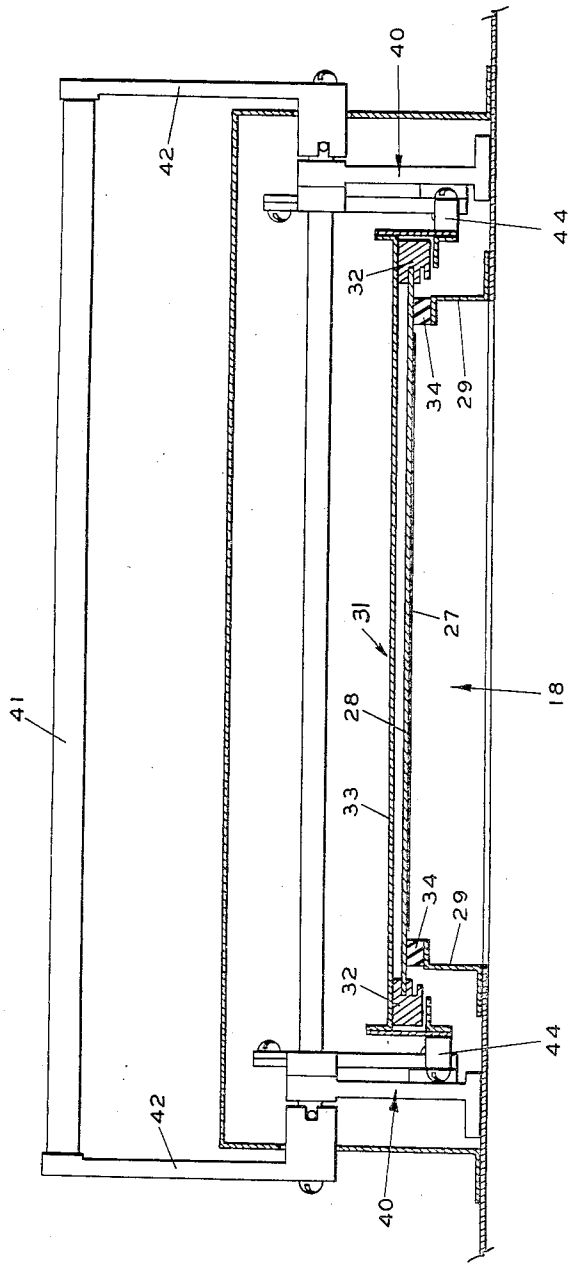


FIG. 4

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APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGE

Filed June 14, 1954 4 Sheets-Sheet 4

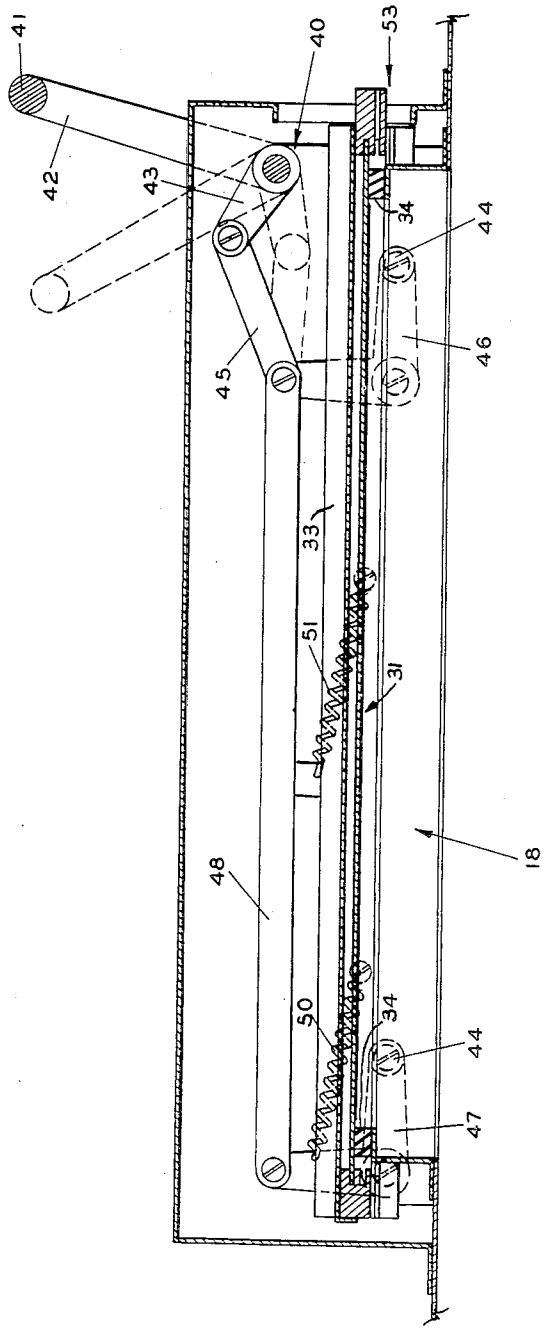


FIG. 5

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2,861,543

APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGE

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Application June 14, 1954, Serial No. 436,482

4 Claims. (Cl. 118—637)

This invention relates in general to xerography and in particular to the development of xerographic images. More specifically, this invention relates in a preferred embodiment to the development of images formed by the action of X-rays in xerography.

In photographic X-ray work using conventional silver halide materials, time-consuming darkroom techniques are necessary before one is able to view the resulting image; whereas in the art of xeroradiography with proper equipment the image may be developed in a few seconds without requiring a darkroom or darkroom techniques and it is therefore an object of this invention to provide means, methods and apparatus which will be procedurally simple and convenient to use in developing xeroradiographic images to enable viewing of the developed image within substantially shorter periods of time than have heretofore been possible.

In the art of xeroradiography as described in Patent No. 2,666,144, a plate composed of a photoconductive insulating layer overlying or coated on a conductive backing member is charged electrostatically and then placed in an exposure position so that radiation projected through an object impinges upon the charged plate. Where radiation strikes and is absorbed by the plate electrostatic charges are released through the insulating layer to the conductive backing member and where radiation is prevented from reaching the plate or is not absorbed, electrostatic charges remain on the plate surface. These charged areas are then developed with fine powder particles so that the radiograph of the image may be examined.

It is an object of this invention to improve upon methods, means and apparatus for developing the xerographic or xeroradiographic image.

It is a further object of this invention to improve the quality of developed xeroradiographic images.

Additional objects of the invention will in part be obvious and will in part become apparent from the following specification and drawings in which:

Fig. 1 is a side view in cross section of one embodiment of the developing apparatus;

Figure 1–A is an enlarged illustration of an embodiment partially in section of the powder supply chamber **16** of Figure 1;

Figure 1–B illustrates partially in section an embodiment of an air drier which might, for example, be located along conduit **23** of the embodiment illustrated in Figure 1;

Fig. 2 is a block diagram of the development apparatus;

Fig. 3 is a cross sectional side view of one embodiment of the nozzle used in the development apparatus;

Fig. 4 is a front view in cross section of the plate positioning area of the development apparatus; and

Fig. 5 is a side cross sectional view of this same element of the apparatus.

Referring to the drawings, in Fig. 1 is shown developing apparatus generally designed as **11** according to one embodiment of the invention including a cabinet or

housing **10** or the like adapted to support and contain the developing apparatus. In a suitable position, such as for example an upper corner, is located a development box or chamber **12** having plate positioning area **18** to receive and support a xeroradiographic plate in a position for development. Preferably, as will be explained hereinafter, the plate is adapted to be supported face downward toward the developing chamber. Positioned to feed into the development box is a nozzle **17** or a source of developing powder material preferably positioned to feed horizontally into the development chamber. At a suitable location a filter assembly comprising baffles **19** and a filter **21** is positioned against exhaust louvers **22** and adapted to release exhaust air from the development chamber while retaining developer powders so as to avoid release of dust into the surrounding air.

Positioned within the cabinet is a compressor assembly comprising a compressor **13**, a motor **9** and a belt **8**. This assembly is adapted to supply compressed air through conduit or tube **23** to a solenoid valve **14**. A second conduit or tube **24** leads from the solenoid valve to a powder supply chamber **16** and in turn to the nozzle **17** whereby the compressed air fed from the compressor is adapted to create a cloud suspension of developer particles and feed this cloud suspension through the nozzle and into the developer box.

A metal rod **7** is mechanically attached and extends between the compressor and the powder supply chamber. This rod causes the vibrations of the compressor to be transmitted to the powder supply chamber and results in constantly agitating the powder in the supply chamber.

In Figure 1–A the powder supply chamber **16** is illustrated in greater detail. Tube **24** feeds into a hole **60** which has attached to the other end thereof jet nozzle **61** and has positioned along its length valves **62** and **63**. Valve **62** controls the air supply and air pressure into the interior chamber **64** of enclosure **65** through tube **66**. Valve **63** controls the feeding out of jet **61**. Positioned within chamber **64** of enclosure **65** is a supply of powder particles **69**. A mixture of powder in air is fed from the interior chamber **64** of enclosure **65** to opening **67**, the output end of powder supply chamber **16**, and then into nozzle **17**. Although a particular supply chamber **16** has been illustrated in this figure, it is to be realized that various other known powder sprayers, atomizers, or the like may be used herein and are intended to be included within the scope of this invention.

In Figure 1–B there is shown an air drier generally designated **68** and comprising an enclosure **70** filled with particles of silica gel **71** or other drying particles such as, for example, calcium chloride or activated alumina. As the air passes through the silica gel the water in the air will be removed to the silica gel material **71**. As illustrated in this figure, the air drier **68** is positioned along conduit **23**.

In Fig. 2 the operation of the electrical and mechanical elements of the embodiment of this invention shown in Fig. 1 are illustrated. Plug **36**, which may be a conventional plug is intended to connect the apparatus through a conventional wall socket to a 110 volt A. C. outlet. Provisions may also be made in the equipment so that different A. C. voltage may be used as well as D. C. voltage. Plug **36** is electrically connected to a switch **37** which when operated places the apparatus in standby condition by supplying electricity to the compressor assembly **6** comprising a motor, a belt and a compressor, all of which have been shown in Fig. 1. While compressor assembly **6** is operating, the compressor makes available compressed air for use in developing a suspension of developer particles in air in

development chamber 12 by feeding compressed air through conduit 23 to solenoid valve 14 and through conduit 24 to powder supply chamber or atomizer 16 where powder is mixed with the air and is fed through nozzle 17. While the equipment remains in standby condition solenoid valve 14 is in a closed position, preventing the supply of compressed air from compressor assembly 6 from reaching atomizer 16. The suspension of developer particles in air is created in development box 12 when compressed air is supplied following the opening of solenoid valve 14 and mixed with developer particles in powder supply chamber 16 and fed through nozzle 17.

To operate the equipment for development purposes once it has been put in standby condition timer switch 38 is closed. This switch is preferably one which may be adjusted through a range of about 60 seconds and one which will consistently repeat the time interval for which it is set. When timer switch 38 is in a closed position and while the equipment is in standby condition, current is supplied to motor-driven cam switch 39 which comprises a cam driven by a motor. The cam, as it rotates, mechanically operates to switch on and off the supply of current to solenoid valve 14 and solenoid valve 14 is thereby repetitively opened and closed while timer switch 38 remains in a closed position during the set time interval. The solenoid valve 14, while going through its open and shut cycle, allows compressed air from compressor assembly 6 to be supplied through tube 24 in a pulsating rhythm. The pulsating compressed air is fed to atomizer 16 which is being mechanically vibrated by rod 7 attached to the vibrating compressor 13, the vibrations acting to keep the powder in atomizer 16 in an agitated state. The powder in powder supply chamber 16 is mixed with the pulsating air and feeds to nozzle 17 in the form of mixed powder in air. The nozzle presents a restrictive zone for the pulsating feed of powder in air to feed through, resulting in a constant supply of powder in air from nozzle 17 to development box 12. With each new pulse of air to atomizer 16, the output from nozzle 17 to development box 12 increases. The output then falls off slowly until a new pulse of compressed air is fed through solenoid valve 14 through tube 24 to atomizer 16.

In Fig. 3 one embodiment of nozzle 17 which presents a restrictive zone for powder in air to feed from atomizer 16 to development box 12 is shown in detail. As indicated in this figure, the size of the internal opening increases in successive steps. One particular or preferred embodiment of nozzle 17 would present an opening of 1/16 inch internal opening to atomizer 16 which increases to 1/8 inch to 1/4 inch to 3/8 inch extending toward development box 12, while the length of each of these openings in the same relative order is .953 inch, 1.657 inches, 3.188 inches and .312 inch. The overall length of this preferred nozzle is 4.75 inches and outside width is .75 inch. Lip 26 shown in this figure is used for mounting purposes, and nozzle 17 is mounted in development box 12 with the larger internal opening at the output end of nozzle 17 and preferably positioned to feed the suspension of particles in air horizontally to development chamber 12.

In Fig. 4, a front cross sectional view of the plate positioning area 18 is shown in detail. Plate 31 is in this view in position for development and is mounted in casette 32. Casette 32 slides into plate support 33 and plate 31 is held in position against rubber gasket 34 mounted on support 29. Plate 31 is composed of normally insulating layer 27, which becomes conductive when exposed to penetrating radiation and conductive backing member 28. Layer 27 is adapted to carry on its surface an electrostatic latent image to be developed in apparatus 11. Rubber gasket 34 is positioned and disposed to contact an area of the front of the plate to which the normally insulating layer 27 does not extend and therefore, gasket 34 is positioned to contact conductive backing member 28 and makes the enclosed area beneath the plate surface air-tight and dust-proof when a plate is in position. The fitting of the gasket tightly against the plate is desirable to prevent the escape of powder particles from the equipment and also to avoid the operation of uncontrolled air currents. Positioned at both sides of the plate is a pressure applying assembly 40 shown generally in this figure and with more particularity in Fig. 5. This assembly acts to supply pressure to plate support 33 or to relieve pressure on plate support 33 through pins 44 connecting plate support 33 and pressure applying assembly 40. When pressure is brought to bear on plate support 33, the plate is moved into position for development against gasket 34. When pressure is released from plate support 33 the plate support 33 is moved vertically upward, allowing free movement of the plate 31 into and out of plate positioning area 18. The movement and control of pressure on plate support 33 may be manually controlled through rod 41, which is connected through handles 42 to pressure applying assembly 40, or it may be moved and controlled through other means to accomplish the same purpose.

In Fig. 5 a side cross sectional view of plate positioning area 18 is shown, wherein the detail of the pressure applying assembly 40 is illustrated. Handle 42 is moved by moving rod 41. Rigidly attached to handle 42 is toggle arm 43. Link 45 is attached to the other end of toggle arm 43. The end of toggle arm 43 rigidly attached to handle 42 is rigidly positioned in plate positioning area 18, while the end of toggle arm 43 attached to link 45 is allowed to move as rod 41 causes it to move. Bell cranks 46 and 47 are attached at their apex to a permanent position in the equipment. Link 48 mechanically joins ends of bell cranks 46 and 47, and movement of link 45 causes movement of bell cranks 46 and 47, the movement of link 45 being transmitted directly to bell crank 46 and through link 48 to bell crank 47. The remaining open ends of bell cranks 46 and 47 are attached to plate support 33 through pins 44 and bring about substantially vertical movement of plate support 33 when rod 41 is manually moved. Spring 50 is attached at one end to the frame of the apparatus while at the other end it is attached to bell crank 47. Spring 51 is attached at one end to the frame of the apparatus and at the other end to link 48. Springs 50 and 51 act to supply pressure causing downward movement of plate support 33 when handle 42 is in the position as shown. When rod 41, which is at the front of plate positioning area 18 (the front being the area through which the plate is inserted and removed) is pushed backwards towards the rear of plate positioning area 18, the pressure on springs 50 and 51 which cause plate 31 to bear against gasket 34, is overcome and plate support 33 is moved to a position to allow free ingress and egress of a plate into and out of plate positioning area 18. The movement of plate support 33 is controlled by the pins 44 attaching bell cranks 47 and 46 to plate support 33. Pressure applying assembly 40 as shown in this diagram exists on both sides of plate positioning area 18, and thereby acts to position plate support 33 by controlling movement near the four corners of plate support 33 through the pins connecting plate support 33 to the bell cranks. An opening generally designated 53 at the front of plate positioning area 18 is to permit ingress and egress of a plate 31 for development purposes.

Pulsating feed of compressed air through atomizer 16 has been found desirable to properly feed developer materials through nozzle 17 and into development box 12 where deposition of powder particles in image formation takes place on the surface of plate 31. While apparatus 11 is in operation, atomizer 16 is provided with a supply of finely divided powder, and it has been found that a continuous flow of compressed air to atomizer 16 results in a powder output of decreasing amount from nozzle 17. Although it is not intended in any way to limit this invention, it is presently felt that a continuous flow of air

to atomizer **16** does not sufficiently stir up powder within the atomizer, and in fact, eventually an equilibrium will be reached where substantially no powder at all is carried to and through nozzle **17**. It is presently thought that a constant air supply tends to pack the powder and cuts a tunnel through it and settled packed powder is substantially undisturbed by the air flow. To avoid this form of equilibrium condition, the powder in atomizer **16** is stirred up by using spurts of air which results in a more constant dispersion of powder in air from nozzle **17** into development box **12**. In addition, the powder is mechanically vibrated by the vibrations transmitted through rod **7**. Agitation of the powder through movement of powder supply chamber **16** has produced a substantial increase in the density of the cloud supplied to development chamber **12**. Other techniques for stirring the powder to obtain a substantially continuous output in development box **12** are intended to be encompassed in this invention. These include but are in no way limited to mechanism to oscillate the atomizer around an axis concentric with the nozzle and the like.

In the equipment illustrated in the drawings it has been experimentally found that for best developing results air pressure in the order of 30 to 50 pounds per square inch should be applied to atomizer **16** while the solenoid valve **14** operates through a continuing cycle during which the valve is opened for 1.5 seconds and closed for 1.5 seconds repetitively. Pulsating atomizer **16** at this rate while using the desired pressures produces a continuing cloud of powder in air in developing box **12**. The on and off supply of compressed air to atomizer **16** causes stirring of the finely divided powder and the nozzle is supplied with a mixture of powder in air which is substantially the same with each spurt of air pressure. A constant cloud of powder in air is supplied to the development box **12** due to the structural formation of the internal opening in nozzle **17** which presents a restrictive zone for the powder mixed in compressed air to feed through and the pressure supplied, and because of the time interval used in the cycle of solenoid valve **14**. An examination of the apparatus in operation shows that just as pressure begins to cut off at the outlet end of nozzle **17**, pressure is substantially increased because of the opening of solenoid valve **14**, or more specifically, while timer switch 38 is in the operating position and following the initial dispersion of powder in air the mixture continues to be disbursed constantly from the output end of nozzle **17**, even though solenoid valve **14** is closed. The output from nozzle **17** decreases during the time solenoid valve **14** is closed but increases again before a zero output point is reached by the opening of solenoid valve **14**. This increases the mixture of powder in air under pressure at the inlet end of nozzle **17** attached to atomizer **16**. While the output from nozzle **17** varies, the cloud within development box **12** of powder in air remains substantially constant. The particles themselves being very fine do not settle readily and the flow of air from the output end of nozzle **17** keeps them in a constant state of agitated flotation.

While many powders have been found to work quite well, and while it would seem that almost any powder would be operative, it is preferred that powders with particle sizes within the range of from .1 to 5 microns be used. The powder should have a substantially uniform particle size throughout within as narrow a size range as possible in order to further uniform development of the electrostatic image. In addition, the particular material the powder is formed of should be selected due to its position in the triboelectric series as it relates to the material the nozzle is composed of and depending on whether it is desired to charge particles positively or negatively as the particles pass through the nozzle. Although it is not intended to limit in any way those powders which may be used successfully with this invention, the best powders found to date include zinc oxide, calcium carbonate and titanium dioxide.

In order to attain uniform development or uniform particle deposition when using development apparatus **11**, it is desirable to have a billowy random flow of powder particles in development box **12**. Such a flow will cause powder to be dispersed in a substantially uniform cloud of powder in air and of cloud throughout all areas of development box **12**. Air currents or air flows which are uncontrolled of more or less definite paths would prevent a uniform distribution of powder in air or would distort the area coverage of the powder cloud within development box **12** thereby interfering with uniform development or deposition of powder particles on areas of plate carrying electrostatic charges. Development box **12** shown in Fig. 1 has a height of 18 inches, a width of 22 inches and a length of 22 inches and although it is presently felt that both maximum and minimum limits exist as to the size and possible shapes of development box **12**, experimentation has shown that large variations are possible without detrimentally affecting the developed image. It is pointed out, however, that other parts of the development apparatus **11** may need compensating changes to match the size or shape of a development box other than as shown, as for example a larger development box of the same general shape as shown in the accompanying drawing will require greater air pressures supplied to atomizer **16**.

Although nozzle **17** is described and shown in this invention in very specific terms, it is not intended in any way to limit this invention to the particular nozzle shown. Any nozzle capable of performing the function of nozzle **17** is intended to be encompassed within the scope of this invention. The nozzle is placed so that a mixture of powder in air under pressure is periodically fed to it and so that it can create in development box **12** a uniformly dispersed mixture of electrostatically charged powder particles in air suspension. The opening in the nozzle is characterized by the fact that it creates turbulent flow of powder in air flowing through it. The opening of nozzle **17**, as shown in Fig. 3, creates such flow when the other previously described conditions such as proper pressures supplied to atomizer **16**, proper action of solenoid valve **14**, proper particle size powder, and the like, are present. Turbulent flow will still be present if minor variations in the opening of nozzle **17** are made; however, major variations in the opening structure are also possible if compensating adjustments are made in other areas, such as the pressure supplied, the form of particle feed, and the like.

Turbulence in nozzle **17** and the material of construction of the nozzle is created out of, or at least the nozzle material which defines the opening of nozzle **17**, controls the electrostatic charge on the powder particles passing through the opening. The nozzle may be composed of any material such as any metal, different forms of rubber, formed plastics, and the like, the particular material being chosen because of its position in the triboelectric series in respect to the particular powder being used and the charge desired, whether positive or negative, depending on the sign, whether positive or negative, of charge making up the electrostatic latent image on the surface of plate 31. Charging of the particles takes place while they pass through nozzle **17** in turbulent flow due to their striking of the material defining the opening of nozzle **17**.

Turbulence also acts to deagglomerate clumps of particles presented to nozzle **17**. Often many of the fine particles in atomizer **16** leave as clusters rather than as individual particles. These clusters or clumps as well as individual particles are fed to nozzle **17**. Such clusters, if deposited on the plate would detrimentally affect the developed image by possibly overlapping into nonimage areas and/or possibly depositing too heavily or unevenly in image areas. One means of preventing such deposition is the turbulent flow which exists in nozzle **17** which

acts to break down these clusters to smaller clumps and to individual particles thereby creating the cloud in development box 12 substantially of individual particles.

Development is accomplished by placing a plate in plate positioning area 18 as indicated in Fig. 4. The surface of plate 31 carrying an electrostatic latent image of the object which has been exposed to penetrating radiation is placed facing downward in development apparatus 11, or, more specifically, facing downward into development box 12. Development apparatus 11, which should be in standby condition, is next placed into operation by throwing the timer switch 38. This brings about the cloud of powder in air substantially of individual particles within development box 12 as previously described. Some clumps or clusters are also carried into the cloud but these clusters will tend to settle downward and away from the area from which particles are drawn for development purposes in that clusters act like larger particles and larger particles are influenced more than smaller individual particles by gravitational forces than by air current forces because the gravitational force on the particle increases at a greater rate than the air current force on the particle as particle size increases. Settlement of clumps or clusters while the individual particles tend to remain in air cloud suspension further assures that clusters of individual particles will not be deposited on the surface of plate 31. It is to be understood of course that a plate positioned at any area of development chamber 12 to which a cloud of developer particles in air suspension devoid of clumps or clusters is presented is intended to be encompassed by this invention.

To further assure the presentation of individual particles rather than clusters or agglomerates of particles to development box 12, it has been found valuable to dehumidify the compressed air fed to atomizer 16. This has been accomplished by cooling the air leaving the compressor by passing this air through a section of finned cooling tubing and then feeding the cooled air through a mechanical water separator or a dessicant chamber as, for example, of the type illustrated in Figure 1–B to remove any condensed water vapor, and following water removal, the compressed air is expanded through a pressure regulating device, such as a reducing valve, before reaching solenoid valve 14, which controls the flow of compressed air to atomizer 16.

The electrostatic latent image on plate 31 is composed of electrostatic charges in image formation. These charged areas will draw to themselves electrostatically oppositely charged powder particles which appear in air cloud suspension in development box 12. The particles in suspension are fine enough and light enough to be influenced by the electrostatic field which is created by the electrostatic latent image on plate 31. Further, the cloud is in a state of constant agitation and billowy random movement so that areas from which particles are drawn to plate 31 are quickly replenished with powder in air suspension thereby creating a new source for an existing electrostatic field to draw on. The development process continues as the electrostatic image attracts particles carrying opposite charges until the electrostatic latent image is fully developed by having attracted sufficient particles carrying opposite charges to counteract and neutralize those charges making up the image.

The electrostatic latent image appearing on plate 31 may be either positive or negative in charge depending on how it was originally formed. If positive, it may be developed by using calcium carbonate as the developer powder for example and a nozzle 17 formed out of cold rolled steel. The particles in such an instance will carry negative charges and will be attracted to the positive charges of the electrostatic latent image. If on the other hand the electrostatic latent image is composed of negative charges, the same developer material may be used if nozzle 17 is formed of aluminum. In this instance the particles will carry positive charges and will be attracted to negative charges of the electrostatic latent image. Development of a reversal image, that is development of areas of no charge rather than areas of charge, may be accomplished by using particles carrying like charges to the charges making up the electrostatic image.

Although the electrostatic latent image will only develop until fully developed, it is desirable to regulate timer switch 38 to cut off development approximately at the point of full development and preferably at a point short of full development. If development is allowed to proceed for too long a period, powder particles carrying like charges to the charges making up the electrostatic latent image, particles which will be present in the cloud, deposit sufficiently in areas of background or discharged areas to produce a flat developed image. On the other hand, sufficient time should be allowed for development to avoid a partially developed or thin image. It is to be noted, however, that although development time is important, it is not critical except within a relatively wide range. For example, in the equipment shown using the other preferred embodiments an electrostatic image on plate 31 can be properly developed during a time interval of from 15 to 35 seconds and preferably for 20 seconds. It is to be understood, however, that modifications may be made which may affect the preferred development time as, for example, the use of another atomizer and nozzle working alternately with atomizer 16 and nozzle 17. The additional powder supply chamber and nozzle may be fed compressed air while compressed air is cut off from atomizer 16 and nozzle 17 thereby creating a denser cloud of powder in air in development box 12 and further reducing the time required for development. With such a modification development time is reduced to a preferred interval of 10 seconds and it is to be understood that further modifications are possible and are intended to be encompassed within the scope of this invention as for example the reduction of height of development box 12, and the like.

Baffles 19 are positioned within development box 12 and act to extend the life of filter 21 which is held in place by louvers 22. The filter is preferably a glass wool filter of sufficient density and of sufficient thickness to allow air to escape from development box 12 while preventing the escape of development particles. Baffles 19 are positioned and disposed in front of the area where filter 21 is found and provide a path for the air flow creating definite flow paths and aiding in creating the billowy random flow of particles in air suspension.

It is to be noted that generally in the art of xerography for high quality development, a development electrode is provided; however, in development apparatus 11, a development electrode is specifically omitted. It has been found experimentally that avoiding such an electrode in apparatus for the development of a radiographed image results in a developed image of greater viewing qualities. The electrostatic image on the plate develops with accentuation of local differences in electrostatic image potential beyond a major area difference. Thus, the present system acts to emphasize slight breaks in the object being X-rayed and thereby results in a developed image of greater sensitivity for X-ray purpose than is otherwise possible.

Carrying out the steps of this invention, a developed image results on the surface carrying the electrostatic latent image of the radiographed object. The developed image may be viewed as it exists on the plate surface or it may be transferred to another surface using procedures and equipment known in the art of xerography, or it may be utilized in other ways such as, for example, photographing the developed image and the like.

While the invention has special advantages in developing xeroradiographic images, and while this application of the invention has been emphasized throughout, it is also contemplated that it can be used to develop other

xerographic images such as line copy images, continuous tone and half tone pictures, and the like.

While the present invention as to its objects and advantages, as has been described herein, has been carried out in a specific embodiment thereof, it is not desired to be limited thereby, but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. Apparatus for the development of an electrostatic image on the surface of an image bearing plate comprising a cabinet including an opening in its upper wall, a source of pressurized gas within said cabinet, a powder supply reservoir within said cabinet connected to said source of gas and adapted to create an output mixture of powder particles and gas when fed with gas, a valve in said cabinet in the connection between said source and said powder supply reservoir, means to open and close said valve to control the feed of gas to said reservoir, a boxlike development chamber within said cabinet extending downward from said opening, plate positioning means at said opening adapted to position and dispose the image bearing surface for development substantially in a horizontal plane while facing downward and in open communication with said development chamber, dust sealing means associated with said plate positioning means to seal the upper end of said development chamber when a plate is in said positioning means, and a restrictive spray nozzle within said cabinet extending into said development chamber and connected to said powder supply reservoir positioned and disposed to spray a mixture of particles and gas fed thereto from said powder supply reservoir substantially horizontally into the development chamber, the elements within said cabinet acting in cooperation to create a billowy random flow of powder particles, from said reservoir, and gas, from said source, in said development chamber for image development.

2. Apparatus for development of an electrostatic image on the surface of an image bearing plate comprising a cabinet including an opening in its upper wall, a source of pressurized gas within said cabinet, a powder supply reservoir within said cabinet connected to said source of gas and adapted to create an output mixture of powder particles and gas when fed with gas, a valve in said cabinet in the connection between said source and said powder supply reservoir, means to intermittently open and close said valve during image development to cause intermittent feed of gas to said reservoir, a boxlike development chamber within said cabinet extending downward from said opening, a filter positioned and disposed in a wall of said chamber, plate positioning means at said opening adapted to position and dispose the image bearing surface for development substantially in a horizontal plane while facing downward and in open communication with said development chamber, dust sealing means associated with said positioning means to seal the upper end of said development chamber when a plate is in said positioning means, and a restrictive spray nozzle within said cabinet extending through a side wall of said development chamber and connected to said powder supply reservoir positioned and disposed to spray a mixture of powder and gas fed thereto from said powder supply reservoir substantially horizontally into the development chamber, said filter allowing gas flow therethrough while resisting passage of particles and the elements within said cabinet acting in cooperation to create in said chamber a continuous and uniform billowy random flow of electrostatically charged powder particles, from said reservoir, and gas, from said source, for image development.

3. Apparatus for development of an electrostatic image on the surface of an image bearing plate in which a uniform billowy random flow of electrostatically charged powder particles is fed beneath the image bearing surface and in the field of influence of the image thereon comprising a cabinet including an opening in its upper wall, a source of pressurized gas within said cabinet, a powder supply reservoir within said cabinet connected to said source of gas and adapted to create an output mixture of powder particles and gas when fed with gas, a valve in said cabinet in the connection between said source and said powder supply reservoir, means to intermittently open and close said valve during image development to cause intermittent feed of gas to said reservoir, a boxlike development chamber within said cabinet extending downward from said opening, plate positioning means at said opening adapted to position and dispose the image bearing surface for development substantially in a horizontal plane while facing downward and in open communication with said development chamber, dust sealing means associated with said positioning means to seal the upper end of said development chamber when a plate is in said positioning means, a restrictive spray nozzle within said cabinet extending to a side wall of said development chamber and connected to said powder supply reservoir positioned and disposed to spray a mixture of powder and gas fed thereto from said powder supply reservoir substantially horizontally into the development chamber, and a filter positioned and disposed in the wall of said chamber opposite to the wall through which the spray nozzle extends and adapted to allow gas passage therethrough while resisting passage of particles, said restrictive nozzle being characterized by its ability to continuously feed a mixture of particles and gas into said development chamber during image development including feeding during that part of the time when said valve is intermittently closed and to cause turbulent flow of the powder particles and gas feeding therethrough to electrostatically charge and deagglomerate the particles.

4. Apparatus according to claim 3 including means to vibrate said powder supply reservoir during image development.

References Cited in the file of this patent

UNITED STATES PATENTS

1,333,079	Kaufmann	Mar. 9, 1920
1,566,800	MacArthur	Dec. 22, 1925
2,028,796	Merritt	Jan. 28, 1936
2,093,995	Blow	Sept. 28, 1937
2,120,003	Schanz	June 7, 1938
2,191,827	Benner et al.	Feb. 27, 1940
2,221,776	Carlson	Nov. 19, 1940
2,280,240	Kathe	Apr. 21, 1942
2,297,691	Carlson	Oct. 6, 1942
2,324,787	Lundgren	July 20, 1943
2,339,899	Wilson	Jan. 25, 1944
2,360,627	Wilson	Oct. 17, 1944
2,375,766	Britcher	May 15, 1945
2,419,835	Hester	Apr. 29, 1947
2,470,580	Scheider et al.	May 17, 1949
2,499,466	De Forest et al.	Mar. 7, 1950
2,518,811	Nicholson	Aug. 15, 1950
2,551,582	Carlson	May 8, 1951
2,597,323	Hiller et al.	May 20, 1952
2,614,528	Britcher	Oct. 21, 1952
2,645,529	Jenner	July 14, 1953
2,711,481	Phillips	June 21, 1955

FOREIGN PATENTS

698,994	Great Britain	Oct. 28, 1953